Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
Description

[0001] The present invention relates to control of power in overhead line electrical distribution systems, and in particular to an operating mechanism for mechanically interlocking the circuit-breaker element of an autorecloser with an associated disconnector to prevent on-load operation of the disconnector.

[0002] Autoreclosers of the type referred to in this specification are intended to be mounted on electricity distribution poles and pylons in overhead line electrical distribution systems. Pole mounted autoreclosers are, in effect, pole mounted circuit breakers connected to control the power flowing in overhead lines. Systems of this type are prone to electrical faults of a transient nature, due to wind blown foliage, birds and lightning strikes. Therefore autoreclosers, as their name suggests, are arranged to open and clear fault current when it reaches a pre-determined level, and then reclose after a pre-determined time interval. In cases where the electrical fault, which causes the autorecloser to open, self-clears during the cessation of current, safe power supply is re-established when the unit recloses. However, autoreclosers are designed to remain in the open position, preventing further electrical current flow, when they have experienced the passage of a pre-determined number of electrical fault currents in a pre-determined sequence of operations. These sequences are usually a selection of instantaneous and fault current dependent time opening operations. When an autorecloser has exhausted its pre-set sequence the fault is deemed to be permanent and it is said to have ‘locked-out’ in the OPEN position. The system then requires manual intervention to carry out repairs at the site of the fault.

[0003] When repairs are to be carried out to the overhead line, operator safety dictates that the line be isolated from the system by the use of a disconnector and, if live-line working is not to be employed, the faulted section is earthed. These disconnectors are off-load switching devices. They provide an isolating gap between their contacts capable of withstanding a much higher impulse voltage level than the impulse voltage which the overhead line itself can withstand, and so provide protection from electrical flashover of one side of the overhead line system to the other. As these are off-load switching devices they have to be interlocked with the circuit-breaker element of the autorecloser to prevent on-load operation.

[0004] The present invention provides an improved form of mechanical interlock between the circuit breaker element of an autorecloser and a disconnector.

[0005] According to the present invention, an autorecloser, in which a circuit breaker is in electrical series with a disconnector, is provided with an operating mechanism comprising shaft means for transmitting motion between first and second ends thereof, the first end being connected to the circuit breaker for moving a moveable contact of the circuit breaker between CLOSED and OPEN positions, the second end being adapted to engage a profile of a rotary crank means, the rotary crank means being attached to means for rotating it, the rotary crank means being further attached to an insulating linkage for moving a moveable contact of the disconnector between CLOSED and OPEN positions, the arrangement being such that when the rotary crank means is rotated in a predetermined direction through a first predetermined angle from a starting position in which the moveable contacts of the circuit breaker and the disconnector are both in the CLOSED position, the moveable contact of the circuit breaker is moved to an OPEN position while the moveable contact of the disconnector is maintained in the CLOSED position, and during further rotation of the rotary crank means in the first direction through a second predetermined angle, the moveable contact of the disconnector is moved to an OPEN position while the moveable contact of the circuit breaker is maintained in the OPEN position, and further that when the rotary crank means is rotated back to its starting position, the moveable contact of the disconnector is moved back to its CLOSED position before the moveable contact of the circuit breaker is moved back to its CLOSED position.

[0006] In order to move the moveable contact of the circuit breaker from the CLOSED to the OPEN position, the profile of the rotary crank means may include a first portion adapted to exert a lever action on the second end of the shaft means during rotation of the rotary crank means through the first predetermined angle.

[0007] The profile of the rotary crank means advantageously further includes a second portion adjacent the first portion, the second portion comprising a sector having a constant radius over an angle at least substantially equal to the second predetermined angle, whereby the moveable contact of the circuit breaker is maintained in the OPEN position during the further rotation of the rotary crank means through the second predetermined angle.

[0008] Conveniently, the means for rotating the rotary crank means comprises a link attached to the rotary crank means at a fixed radial distance from the centre of rotation of the rotary crank means.

[0009] The moveable contact of the disconnector may comprise a contactor link hinged at one end thereof to fixed contact means so that an opposing free end of the contactor link can be moved into and out of engagement with further fixed contact means thereby respectively to CLOSE and OPEN the disconnector. This may be achieved by pivotally connecting the contactor link at a location between its hinged end and its free end to an end of the insulating linkage which at an opposed end thereof is pivotally connected to the rotary crank means at a location thereon which is a fixed radial distance from the centre of rotation of the rotary crank means and a fixed angular distance from the first portion of the profile of the rotary crank means.

[0010] The shaft means is conveniently also part of
an actuator element of the autorecloser for automatically driving the moveable contact of the circuit breaker into its OPEN and CLOSED states.

[0011] Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a single line electrical diagram of the connections for an autorecloser comprising a circuit breaker and a disconnector in series;

Figures 2, 3A and 4 show three different positions of an operating linkage in accordance with the present invention, for use in association with the autorecloser of Figure 1 and;

Figure 3B is an enlargement of part of Figure 3A, illustrating the motions of the mechanism during the transition between the positions of Figures 2 and 3A.

[0012] In Figure 1, an autorecloser 1 comprises a disconnector 2 in series with a circuit breaker element 3. The circuit breaker 3 and the disconnector 2 are integrated with each other in that they are provided with mechanical and electrical interlocks to prevent on-load operation of the series disconnector 2, because as explained above, it is an off-load switching device. The present invention as described below in relation to Figures 2 to 4 provides the required mechanical interlock system.

[0013] The interlock system must meet some important criteria, as follows;

(1) A local manual opening operation should automatically fully open the autorecloser circuit breaker contacts, with the disconnector contacts held in full electrical contact, before moving the disconnector to the OPEN position.

(2) With the autorecloser circuit breaker contacts CLOSED, it must not be possible to move the disconnector contacts from a position where they have full electrical contact without first opening the circuit breaker.

(3) The disconnector should be free to be opened when the autorecloser circuit breaker contacts are OPEN.

(4) The autorecloser circuit breaker contacts will only be free to close when the disconnector is closed and its contacts have full electrical contact.

(5) When the disconnector is being operated toward the CLOSED and OPEN positions, and when in the OPEN position, it must not be possible to close the autorecloser circuit breaker contacts.

[0014] Referring now to Figure 2, there is shown an operating mechanism according to the invention. In the mechanism, a series disconnector 2 has fixed contacts 10, 30 and a moving contact 20 which is hinged to the fixed contact 30 by a hinge pin 32. Fixed contact 10 is connected to the electrical power circuit via bushings, not shown, and fixed contact 30 is rigidly connected to a fixed contact of the circuit breaker, not shown, via electrical bushings, also not shown. The power electrical path through the unit is therefore through external electrical bushings, the disconnector fixed contact 10, the disconnector moving contact 20, the disconnector fixed contact 30, the circuit breaker fixed contact, the circuit breaker, and a final set of external bushings, not shown.

[0015] The autorecloser circuit breaker 3, see Figure 1, is mechanically linked to the drive element 80. Drive element 80 may be of the magnetic actuator type. In the embodiment shown in Figure 2, drive element 80 is directly connected through drive shaft 82 at its right hand side to the autorecloser circuit breaker, thereby to OPEN and CLOSE the circuit breaker contacts by a linear backwards and forwards motion between two fixed positions, as indicated by a double-headed arrow. Drive shaft 82 also extends through the centre of the drive element 80 to emerge at its left hand side. Drive shaft 82 has a flanged end 40 at its left hand extremity, the back face of which is intended to engage with a bell crank 50. This bell crank is arranged to rotate on a fixed axis pin 52 and is connected through radially outer pivot point 54 to a drive link 60 manufactured from insulating material. The remote end of drive link 60 is connected to the disconnector moving contact 20 through pivot 22 about a third of the way along the length of contact 20 from fixed hinge pin 32. The arrangement is such that rotation of the bell crank 50 will cause the disconnector contact 20 to move towards the OPEN or CLOSED position, depending upon the direction of rotation of bell crank 50.

[0016] Also connected to bell crank 50 at a radially outer pivot point 56 is a link 70, which is arranged to move up and down in a vertical direction as shown by the double-headed arrow. Link 70 is the means by which manual operation of the disconnector 2 is carried out. Upward movement of link 70 causes the bell crank 50 to move in an anti-clockwise direction, while downward movement causes clockwise bell crank movement.

[0017] As seen in Figures 2 to 4, the bell crank 50 is provided with a special two-part cam profile for engagement with the flange 40 of shaft 82. A first part 57 of the cam profile is straight, ending at a corner 58. A second part 59 extends from corner 58 as a curve of constant radius centred on the axis of the fixed pivot 52.

[0018] The mechanism in Figure 2 is shown in the position which it adopts when both the series disconnector 2 and the autorecloser circuit breaker 3 are the CLOSED position, the disconnector moving contact 20 being in full electrical contact with fixed contact 10. Starting from this position, with the straight part 57 of the cam profile lying parallel to the rear face of flange 40, downward movement of the link 70 rotates the bell crank 50 clockwise, causing its bottom left corner 58 to engage the rear face of flange 50 at the left end of drive shaft 82. As the rotation of bell crank 50 continues, the corner 58 of the
cam profile exerts a lever action on flange 40 so that it is pushed to the position shown in dotted outline, this being the position it assumes when the autorecloser circuit breaker is in the OPEN position.

[0019] Figure 3A illustrates the configuration of the entire mechanism when the circuit breaker is in the OPEN position, the starting position of flange 40 in Figure 2 being shown in dashed lines. It will be noticed that even though the bell crank 50 has been angularly rotated through about 30 degrees, the movable contact 20 is still in substantially the same position it was in Figure 2, i.e. the disconnecter 2 is still in the CLOSED condition. Figure 3B illustrates the reason for this more clearly.

[0020] It will be seen from Figure 3B that as link 70 is pulled down, the centre of pivot pin 56 on radius R1 moves from position A to position B, through an angle of X degrees. Angle X was designated as about 30 degrees in the preceding paragraph, though this angle and other dimensional characteristics of the mechanism can of course be varied to suit any particular design requirements. Similarly, point 58 on radius R2 moves through angle X from position C to position D, pushing flange 40 to the left, and the centre of pivot pin 54 on radius R3 moves through angle X from point E to point F. At the same time, it can be seen that the line R4 extending between the centres of pivot pins 22 and 54 has moved through an angle Y. If a circle G centred on the centre of fixed pivot pin 52 is drawn through points E and F and a circle H centred on the centre of pin 22 on movable contact 20 is also drawn through points E and F, it will be noted that there is only a very small overlap of the circles, indicating that there is little movement of the pivot 22 relative to the fixed pin 52. Hence, movable contact 20 does not move out of engagement with fixed contact 10 as the circuit breaker moves from the CLOSED position in Figure 2 to the OPEN position in Figure 3A, fulfilling the above criteria (1) and (2).

[0021] At the point shown in Figures 3A and 3B, further downward movement of the link 70 will bring the rear face of flange 40 into contact with the second part 59 of the cam profile on bell crank 50 as it rotates further clockwise. This cam face 59 is of constant radius, thereby maintaining the drive shaft 82 in the same position so that the circuit breaker cannot CLOSE. At the same time, as pivot pin 54 moves clockwise around circle G, link 60 pulls movable contact 20 down and away from fixed contact 10, so moving it to the OPEN position, as shown in Figure 4. This fulfils criterion (3), above.

[0022] It will now be seen from Figure 4 that further downward pulling of link 70, if allowed, could only rotate the bell crank 50 further clockwise by a limited amount, at most until pivot pin 56 is directly underneath fixed pivot 52. At this point, cam face 59 would still be in contact with flange 40, again ensuring that flange 40 is prevented from moving towards the CLOSED position. However, it is in fact arranged that after flange 40 has begun to engage cam face 59, the bell crank 50 can only be rotated through a further angle Z to a predetermined limit of movement, so that after movement through angle Z has been achieved, further clockwise rotation of the bell crank 50 from the position shown in Figure 4 is prevented. Hence, criterion (5) above is fulfilled because the disconnecter contact 20 is mechanically free to be driven back to the CLOSED position by upward movement of drive link 70, causing the bell-crank 50 to rotate anticlockwise and thus drive the insulating link 60 upwards.

[0023] Prevention of further rotary movement of bell crank 50 after it has turned through the angle X + Z can readily be achieved by means of a suitable stop in the mechanism; for instance, an abutment may be arranged between a lug (not shown) on the bell crank 50 and a further lug (not shown) on a stationary support structure.

[0024] Clearly, there is nothing in this invention which prevents the additional use of electrical interlocks and/or auxiliary switches to help in meeting the operational requirements listed, and it would be prudent to have such devices. However, this invention will ensure the requirements are always met, even in the event of loss of electrical power to the operating mechanism.

[0025] Although link 70 has been described as the means by which manual operation of the disconnecter 2 is carried out, the invention is not restricted to such manual operation. Clearly, it is at the option of the designer also to connect the link 70 to a linear magnetic actuator or a motorised rack-and-pinion mechanism, for example, in order to provide for remote or automatic operation of the disconnecter in addition to provision of manual operation as a last resort.

Claims

1. An autorecloser (1) in which a circuit breaker (3) is in electrical series with a disconnecter (2), the autorecloser being provided with an operating mechanism comprising shaft means (82) for transmitting motion between first and second ends thereof, the first end being connected to the circuit breaker for moving a movable contact of the circuit breaker between CLOSED and OPEN positions, characterised in that the second end (40) is adapted to engage a profile (57,58,59) of a rotary crank means (50), the arrangement being such that when the rotary crank means is rotated in a predetermined direction through a first predetermined angle (X) from a starting position in which the movable contacts of the circuit breaker and the disconnecter are both in the CLOSED position, the movable contact of the circuit breaker is moved to an OPEN position while the movable contact (20) of the disconnecter is maintained in the CLOSED position, and during further rotation of the rotary crank means in the first direction through a second predetermined angle (Z), the movable contact (20) of the disconnecter is moved to an OPEN position while the movable
contact of the circuit breaker is maintained in the OPEN position, and further that when the rotary crank means (50) is rotated back to its starting position, the moveable contact (20) of the disconnector moves back to its CLOSED position before the moveable contact of the circuit breaker moves back to its CLOSED position.

An autorecloser according to claim 1, in which the profile of the rotary crank means (50) includes a first portion (57/58) adapted to exert a lever action on the second end (40) of the shaft means (82) during rotation of the rotary crank means through the first predetermined angle (X).

3. An autorecloser according to claim 2, in which the profile of the rotary crank means (50) includes a second portion (59) adjacent the first portion (57/58) comprising a sector having a constant radius (R2) over an angle at least substantially equal to the second predetermined angle (Z), whereby the moveable contact of the circuit breaker (3) is maintained in the OPEN position during the further rotation of the rotary crank means to a predetermined limit of movement.

An autorecloser according to any preceding claim, in which means for rotating the rotary crank means (50) comprises a link (70) attached to the rotary crank means at a fixed radial distance (R1) from the centre of rotation of the rotary crank means.

5. An autorecloser according to any preceding claim, in which the moveable contact of the disconnector (2) comprises a contactor link (20) hinged at one end thereof to fixed contact means (30) so that an opposing free end of the contactor link can be moved into and out of engagement with further fixed contact means (10) thereby respectively to CLOSE and OPEN the disconnector.

6. An autorecloser according to claim 5 as dependent on claim 2 or claim 3, in which the contactor link (20) is pivotally connected at a location (22) between its hinged end and its free end to an end of a further link (60) which at an opposed end thereof is pivotally connected to the rotary crank means (50) at a location (54) thereon which is a fixed radial distance (R3) from the centre of rotation of the rotary crank means and a fixed angular distance from the first portion of the profile of the rotary crank means.

7. An autorecloser according to any preceding claim, in which the shaft means (82) is also part of an actuator element (80) of the autorecloser for automatically driving the moveable contact of the circuit breaker (3) into its OPEN and CLOSED states.

**Patentansprüche**

1. Automatischer Wiedereinschalter (1), bei welchem ein Ausschalter (3) mit einem Trennschalter (2) elektrisch in Reihe geschaltet ist, wobei der automatische Wiedereinschalter mit einem Betätigungsmechanismus versehen ist, welcher eine Welleneinrichtung (82) zum Übertragen einer Bewegung zwischen einem ersten Ende und einem zweiten Ende von ihr umfasst, wobei das erste Ende mit dem Ausschalter verbunden ist, um einen beweglichen Kontakt des Ausschalters zwischen einer SCHLIESS- und einer OFFEN-Stellung zu bewegen, dadurch gekennzeichnet, dass das zweite Ende (40) dazu ausgelegt ist, in ein Profil (57,58,59) einer Drehkurbeleinrichtung (50) einzugreifen, wobei die Anordnung so gewählt ist, dass beim Drehen der Drehkurbeleinrichtung aus einer Ausgangsstellung, in der sich die beweglichen Kontakte des Ausschalters und des Trennschalters befinden, um einen ersten vorbestimmten Winkel (X) in eine vorbestimmte Richtung der bewegliche Kontakt des Ausschalters in die OFFEN-Stellung bewegt wird, während der bewegliche Kontakt (20) des Trennschalters in der SCHLIESS-Stellung verbleibt, und dass der bewegliche Kontakt (20) des Trennschalters beim Weiterdrehen der Drehkurbeleinrichtung um einen zweiten vorbestimmten Winkel (Z) in die erste Richtung in eine OFFEN-Stellung bewegt wird, während der bewegliche Kontakt des Ausschalters in der OFFEN-Stellung verbleibt, und dass ferner beim Zurückdrehen der Drehkurbeleinrichtung (50) eine Hebewirkung auf das zweite Ende (40) der Welleneinrichtung (82) auszüuben.

2. Automatischer Wiedereinschalter nach Anspruch 1, bei welchem das Profil der Drehkurbeleinrichtung (50) einen ersten Abschnitt (57/58) aufweist, der dazu ausgelegt ist, beim Drehen der Drehkurbeleinrichtung um den ersten vorbestimmten Winkel (X) eine Hebewirkung auf das zweite Ende (40) der Welleneinrichtung (82) auszüuben.

3. Automatischer Wiedereinschalter nach Anspruch 2, bei welchem das Profil der Drehkurbeleinrichtung (50) einen zum ersten Abschnitt (57/58) benachbarten zweiten Abschnitt (59) aufweist, der einen Bereich mit einem konstanten Radius (R2) über einen Winkel von mindestens gleich dem zweiten vorbestimmten Winkel (Z) hinweg umfasst, wodurch der bewegliche Kontakt des Ausschalters (3) beim Weiterdrehen der Drehkurbeleinrichtung bis zu einer vorbestimmten Grenze für die Bewegung in der OFFEN-Stellung gehalten wird.
4. Disjoncteur à réenclenchement automatique (1) dans lequel un disjoncteur (3) est électriquement connecté en série avec un sectionneur (2), le disjoncteur à réenclenchement automatique étant muni d’un mécanisme de fonctionnement comprenant un arbre (82) pour transmettre un mouvement entre une première et une seconde extrémités de celui-ci, la première extrémité étant connectée au disjoncteur pour actionner un contact mobile du disjoncteur entre des positions FERME et OUVERT, caractérisé en ce que la seconde extrémité (40) est adaptée pour s’accoupler au profil (57, 58, 59) d’un mécanisme à manivelle rotatif (50), l’arrangement étant tel que lorsque le mécanisme à manivel-
çon respectivement FERMER et OUVRIR le sectionneur.

6. Disjoncteur à réenclenchement automatique selon la revendication 5 dépendante de la revendication 2 ou de la revendication 3, dans lequel la biellette de contacteur (20) est connectée sur pivot au niveau d'un point (22) situé entre son extrémité montée sur gond et son extrémité libre à une extrémité d'une autre biellette (60), laquelle, à son extrémité opposée, est connectée sur pivot au mécanisme à manivelle rotatif (50) au niveau d'un point (54) où sont définies une distance radiale fixée (R3) à partir du centre de rotation du mécanisme à manivelle rotatif et une distance angulaire fixée à partir de la première partie du profil du mécanisme à manivelle rotatif.

7. Disjoncteur à réenclenchement automatique selon l'une quelconque des revendications précédentes, dans lequel l'arbre (82) fait également partie d'un élément actionneur (80) du disjoncteur à réenclenchement automatique pour entraîner automatiquement le contact mobile du disjoncteur (3) dans ses états OUVERT et FERME.
Fig. 3B